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Meeting American Diabetes Association diabetes management targets: trends in Mauritius

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What's new?

- This study in Mauritius is one of the first assessments of the trends in the achievement of treatment targets among people with diabetes in a lower- or middle-income country.
- In Mauritius, the control of glycaemia and blood pressure was better in 2015, compared with the year 2009.
- From 2009 to 2015, no significant differences were observed in levels of total cholesterol and LDL cholesterol.
- In Mauritius, the majority of people with diabetes continue to have inadequately controlled HbA_{1c}, blood pressure and lipids, highlighting the need for further improvements in diabetes management.

Aims To examine the proportion of people with diabetes in the multi-ethnic country of Mauritius meeting American Diabetes Association targets in 2009 and 2015.

Methods Data from independent population-based samples of 858 and 656 adults with diagnosed diabetes in 2009 and 2015, respectively, were analysed with regard to recommended American Diabetes Association targets for HbA_{1c}, blood pressure and LDL cholesterol.

Results In 2015 compared with 2009, the proportion of people achieving American Diabetes Association targets for glycaemic control in Mauritius was higher in women ($P \leq 0.01$) and in those with only a primary education level ($P = 0.07$), but not in men or people with a higher level of education. Achievement of blood pressure $< 140/90$ mmHg was higher in 2015 compared with 2009 (60% vs 42%) in people of South Asian ethnicity ($P < 0.001$), but not in

those of African ethnicity ($P=0.16$). The percentages of people with LDL cholesterol <2.59 mmol/l were 42.1% and 50.4%, in 2009 and 2015, respectively ($P=0.27$). Better control of HbA_{1c} and blood pressure was observed in groups in which that control was poorest in 2009. The use of glucose-, blood pressure- and LDL cholesterol-lowering medication was higher in 2015 than in 2009.

Conclusions In certain subgroups, namely women, those with poorer education and those of South Asian ethnicity, whose target achievement was the poorest in 2009, control of glycaemia and blood pressure was better in 2015 as compared with 2009. While these findings are encouraging, further work is required to improve outcomes.

Introduction

Type 2 diabetes represents a substantial human, social and economic burden, especially in low- and middle-income countries [1]. Previous studies in Mauritius, a rapidly developing economic nation with a mixed ethnic population of South Asian, African Creole and Chinese people, have demonstrated a substantial increase in the prevalence of diabetes over 22 years [2,3]. The age-standardized prevalence of diabetes was 13.0% in 1987 and increased to 21.3% in 2009 in people aged 25–74 years [2]. Given this high prevalence of diabetes, appropriate management of diabetes is important to prevent the development of high rates of diabetes complications.

Metabolic control of Type 2 diabetes involves addressing three key areas: glycaemia, blood pressure and lipid levels. The American Diabetes Association (ADA) 2016 guidelines recommend that most adults with diabetes should achieve an HbA_{1c} concentration <53 mmol/mol (7.0%), blood pressure $<140/90$ mm Hg, and LDL cholesterol <2.59 mmol/l [4]. These recommendations are in line with those developed in many other countries [5]. In 2009, the ADA recommendation for adequate control of blood pressure was $<130/80$ mmHg [6–8], while the other targets were the same for both 2009 and 2015.

Over the last two decades, the proportion of those with diabetes who met the [Hb]A_{1c}, blood pressure and cholesterol, or 'ABC', goals have increased in many countries [9,10]. Despite the high diabetes prevalence in low- and middle-income countries, studies examining the status and quality of diabetes management according to ABC goals are rare in these countries [9,11–13].

Because Mauritius has regular national health surveys (usually every 5 years), and has a multi-ethnic population with a high diabetes prevalence, it is an ideal place to assess the trends in the proportions of people with diabetes attaining the ADA ABC targets at the population level.

Research design and methods

Survey design

Mauritius is a country in the Indian Ocean with a population of 1.3 million people, and comprises different ethnicities, including South Asian, African (Creole) and Chinese. Non-communicable disease surveys were conducted in 2009 and 2015 by the Ministry of Health and Quality of Life in collaboration with several international research institutions [14,15]. The two survey populations were selected independently of each other using cluster-based sampling (Appendix S1). The response rates for the 2009 and 2015 surveys were 85% and 87%, respectively. Written informed consent was obtained from all participants in both surveys. Both surveys were approved by the ethics committee of the Ministry of Health and Quality of Life, Mauritius. The present study was also approved by Monash University Human Research Ethics Committee and the Alfred Ethics Committee, Australia.

Data collection and samples

To collect demographic, medication use and medical history information, identical questionnaires were used in both 2009 and 2015. The date on which participants were first diagnosed with diabetes, ethnicity, educational level, type of treatment and medication use were obtained using interviewer-administered surveys. The level of education was categorized as primary (0–6 years' of education), secondary (7–12 years), or tertiary (>12 years). Based on self-report ethnicity, participants were categorized as South Asian, African or other. Duration of diabetes was categorized into three subgroups as <5, 5–10 and ≥10 years. Participants self-reported whether or not they were taking medications for diabetes, hypertension or hyperlipidaemia, and were asked to specify the names of drugs. In 2015, 49% of medications were confirmed by participants bringing their prescriptions or medications with them to the survey.

The present analysis included all men and non-pregnant women aged 20–75 years with previously diagnosed diabetes. Diabetes was defined as self-report of a previous diagnosis of

diabetes, and was confirmed by either fasting plasma glucose ≥ 7.0 mmol/l or 2-h plasma glucose after a 75-g glucose load ≥ 11.1 mmol/l, or use of glucose-lowering medications. The 2-h glucose tolerance test was not conducted among those participants who were on glucose-lowering medications.

Measurements and laboratory tests

Weight was measured with the participant in light clothing, using a mechanical beam balance in 2009 and using electronic scales in 2015. Height was measured using a stadiometer in both surveys. BMI was calculated by dividing the weight (kg) by the square of the height (m). Participants were defined as overweight or obese if the BMI was ≥ 25 and ≥ 30 kg/m², respectively, in African participants, and ≥ 23 and ≥ 27 kg/m² in South Asian and Chinese participants [16]. Blood pressure was measured three times using an automated blood pressure monitor (Omron Digital Auto Blood Pressure Monitor SEM-1 in 2009 and Omron Digital Auto Blood Pressure M7 in 2015) by a trained operator. All three measurements were averaged to give a mean blood pressure.

Blood samples were collected by venepuncture after an overnight fast of at least 8 h (hours since last meal was self-reported). In 2009, blood samples were collected in fluoride/oxalate tubes centrifuged directly after drawing and samples were then tested using a YSI 2300 STAT PLUS instrument on site. In 2015, samples were collected in fluoride/oxalate tubes, kept at 4°C for 1–3 hours and transferred to a central laboratory (Victoria Hospital in Quatre-Bornes) and assayed using a similar YSI instrument. Glucose stability studies were conducted to confirm that the samples collected for glucose assay reached the laboratory without any deterioration or undergoing glycolysis (Appendix S1). For HbA_{1c} testing, samples were collected in EDTA tubes and assayed on a Tosoh G7 automated system using high-performance liquid chromatography, in both 2009 and 2015. Serum triglycerides, total cholesterol and HDL cholesterol were measured using enzymatic methods adapted on the automated system of Targa 3000+ Biotechnica equipment and Abbott Architect c8000 in 2009 and 2015, respectively. LDL cholesterol was calculated on participants with triglycerides ≤ 4.52 mmol/l, using the Friedewald formula [17].

Statistical methods

Statistical analysis was performed using STATA (version 14; Stata Corp, College Station, TX, USA). Changes in mean values over time were tested using regression models adjusted for

age, sex and duration of diabetes. Change in the prevalence of 'ABCs' between the two surveys was analysed by logistic regression, adjusted for age, sex and duration of diabetes, with each ABC domain as the outcome, and the year of the survey as the independent variable. We tested for interactions of sex, ethnicity, education, and duration of diabetes with a change in the proportions reaching the targets of HbA_{1c}, lipids and blood pressure between 2009 and 2015. We explored effect measure modification (departure from a multiplicative effect) by performing stratified analysis when the interaction term had a *P* value ≤ 0.2 . *P* values < 0.05 were taken to indicate statistical significance. Serum triglyceride, HDL cholesterol, HbA_{1c} and fasting plasma glucose levels were log transformed to correct for the skewed distribution and reported as medians (interquartile range). There were very few missing data (maximum number of missing =41, for duration of diabetes), except for type of medication, where data were available for 1007 of the 1283 participants who reported they were taking medication.

Results

Population characteristics

Characteristics of the study populations are shown in Figure 1. The generalizability of the survey to the total population of Mauritius is described in the Appendix. The age- and sex-standardized prevalence of Type 2 diabetes in the Mauritian population aged 18–74 years was estimated at 20.5% in 2009 and 19.2% in 2015. The total study population comprised 1514 people with known diabetes, 858 from 2009 and 656 from 2015 (Table 1). Overall, characteristics of the participants were similar in both surveys, but there were more people aged >55 years in 2015 ($P<0.001$). Compared with 2009, the median age and mean BMI were higher, and the median duration of diabetes was longer in 2015. The proportion of smokers in men was 30.7% in 2009 and 22.3% in 2015 ($P=0.007$). Very few women smoked in either survey.

Median fasting plasma glucose levels were lower in both men ($P=0.03$) and women ($P<0.001$) in 2015 than in 2009, and the median HbA_{1c} was significantly lower in women ($P<0.001$) but not in men ($P=0.27$; Table 1). Serum HDL cholesterol and LDL cholesterol levels did not change significantly from 2009 to 2015, but the median triglyceride level was higher by 0.1 mmol/l in 2015 ($P<0.001$). Mean systolic blood pressure was lower in 2015 compared with 2009.

Medication

Overall, glucose-lowering medication use was higher in 2015 compared with 2009 (Table 1). The proportion of participants on monotherapy was 33% in 2009 and 40% in 2015 ($P=0.002$). Of the 1283 participants who reported they were taking glucose-lowering medication, 1007 provided details on the type or brand name of such drugs. The percentage of participants on dual or triple therapy was also higher in 2015 compared with 2009 ($P<0.001$). The proportion of people on insulin therapy was not significantly different between the two surveys. Metformin use was higher in 2015 (66%) compared with 2009 (43%; $P<0.001$). Statin use was higher in 2015 (37%) compared with 2009 (19%; $P<0.001$). In participants aged >50 years, statin use was 21.8% and 40.2% in 2009 and 2015, respectively ($P<0.001$). Use of anti-hypertensive medication was 30.9% in 2009 and 52.1% in 2015 ($P<0.001$).

Achievement of targets

Glycaemic control

In 2009, only 23% of men and 15% of women achieved the ADA target of $\text{HbA}_{1c} <53$ mmol/mol ($<7\%$; Table 2). These proportions reached $\sim 22\%$ in 2015 in both men ($P=0.45$) and women ($P=0.01$). Among women, achievement of each of the three HbA_{1c} targets of 53 mmol/mol ($<7\%$), 64 mmol/mol ($<8\%$) and 75 mmol/mol ($<9\%$) was higher in 2015 as compared with 2009. While, such differences were not observed in men (P values for the interactions with sex at the three HbA_{1c} thresholds ≤ 0.03). In 2015 compared with 2009, the proportion of participants reaching the HbA_{1c} target <64 mmol/mol ($<8\%$) was significantly higher in those with primary or no formal education, but not in those with secondary and tertiary levels of education (P value for the interactions = 0.10). Among people with <5 years' diabetes duration and also those with >10 years', HbA_{1c} targets of <64 mmol/mol ($<8\%$) and $<9\%$ (<75 mmol/mol) were achieved more often in 2015 than in 2009.

Blood pressure

The proportion of participants reaching the blood pressure target $<140/90$ mmHg was significantly higher in 2015 (57.9%) compared with 2009 (42.1%; Table 3). There was a significant interaction of ethnicity and reaching blood pressure target (P value for interaction = 0.09). In 2015, the proportion who reached the blood pressure target $<140/90$ was higher among South Asian participants ($P<0.001$) but not in the African subgroup ($P=0.16$).

Achievement of the lower blood pressure target of <130/80 mmHg was 22.6% and 33.0% in 2009 and 2015, respectively ($P<0.001$).

LDL cholesterol

The proportion of people reaching the ADA target of LDL cholesterol <2.59 mmol/l was not different between 2009 and 2015 ($P=0.14$). In 2015, >50% of men and 60% of women still had LDL cholesterol levels >2.59 mmol/l (Table 3).

All three ABC targets

The proportion of participants reaching all three ABC targets [HbA_{1c} <53 mmol/mol (<7%), LDL cholesterol <2.59 mmol/l and blood pressure <140/90 mmHg] was 2.9% in 2009 and 6.7% in 2015 ($P=0.002$). Using the blood pressure target of <130/80 mmHg, the proportion of people reaching all three targets was only 1.6% in 2009 and 5% in 2015 ($P<0.001$).

Discussion

The major findings of this study were that, in people with diabetes in Mauritius, the glycaemic control and blood pressure control was better in 2015 than in 2009, while there was no difference in mean LDL cholesterol levels. The proportion achieving HbA_{1c} <64 mmol/mol (<8.0%) and <75 mmol/mol (<9.0%) and blood pressure <140/90 mmHg (and 130/80 mmHg) was higher in 2015 than in 2009.

It is important to note that higher achievement rates of ABC targets were primarily observed in groups with the poorest control in 2009. This was particularly true for glycaemic control of HbA_{1c} <64 mmol/mol (<8.0%) and HbA_{1c} <75 mmol/mol (<9.0%), but not at the target level of HbA_{1c} <53 mmol/mol (<7.0%). Furthermore, significantly better control of glycaemia was seen in women in the year 2015, but not in men. In 2009, women had a higher median level of HbA_{1c} than men. The improvements we observed in HbA_{1c} levels in people with a lower level of education may indicate a narrowing of some of the health inequalities in people with Type 2 diabetes since 2009, which is encouraging. The higher proportion of people achieving targets in 2015 was paralleled by a greater use of medications for these three conditions, but it is not possible to ascertain to what extent medications or other factors led to the observed improvements. the proportion of people who reached the ABC targets specified by ADA,

however, is still suboptimal, with 95% of people with diabetes not attaining all three ABC targets in 2015.

As compared with other studies, the proportion of participants with HbA_{1c} <53 mmol/mol (<7%) is lower in Mauritius. In 2009 in Mauritius, <20% of the participants had HbA_{1c} <53 mmol/mol (<7%), while in a US study this proportion was >50% in the time period of 2007 to 2010 [19]. While the percentage of participants reaching the HbA_{1c} target <53 mmol/mol (<7%) did increase to 21.8% in 2015 in Mauritius, it is still lower than other countries where such data are available [9].

The percentage of participants reaching the blood pressure targets <130/80 mmHg and <140/90 mmHg in Mauritius was higher or at least similar to clinic-based studies conducted in Poland [20], Taiwan [9], India [13] Iran [11] and Singapore [13]; however, better blood pressure control was reported in population-based data from the USA [19]. While blood pressure control improved in other ethnicities, no improvement was observed among Africans in Mauritius. Previous studies also report ethnic disparity in blood pressure control among people with Type 2 diabetes. In a cohort study conducted in the UK, blood pressure increased significantly in people of Afro-Caribbean ethnicity as compared to those of white European ethnicity over 9 years [13]. These differences may be attributable to genetic or epigenetic differences, access to healthcare, different diets, different smoking levels and other lifestyle factors.

Better control of blood pressure and glycaemia in people with diabetes in Mauritius in 2015 is likely to be partially attributable to more widespread use of medication, although for glycaemia it is notable that the increase was mainly in the use of oral medication, not insulin. Increasing public awareness about diabetes and changing lifestyle might also contribute to this improvement. Another contributor to better control of blood pressure and glycaemia may have been the addition of diabetes nurse educators in several clinics. In May 2014, 58 diabetes nurses were introduced to selected diabetes clinics in Mauritius to help to educate people about a healthy lifestyle, including diet and physical activity and to teach people how to improve self-management of diabetes and encourage the adherence to medication.

A meta-analysis showed that involving nurses in chronic disease management improved blood pressure and glycaemia in Type 2 diabetes [21]. There are some other approaches that might result in improved diabetes management in Mauritius, such as introducing awareness campaigns and improved healthcare structure, improving diabetes self-management,

educating healthcare professionals and identifying or developing additional resources to improve diabetes management.

The change in triglyceride levels may have been attributable to the higher BMI in 2015 [22]. The reason that LDL levels were not lower in 2015 is not clear. Statin use did indeed increase from 19.2% to 37.8%, but we do not have data on adherence; poor adherence to statin therapy may have contributed to this lack of change in LDL cholesterol levels [23].

The 3.4% increase in the proportion of participants who attained all three ABC targets set out by the ADA is lower but similar to other countries [4]. For example, a national survey in Taiwan showed that the attainment of all ABC goals increased by 4.3% from 2006 to 2011 [9]. Studies in the US population indicated achievement of all three targets has improved in the previous two decades [10,19,24–26].

The Swedish quality register of diabetes ($n=384\,124$) reported that the proportion of people with controlled HbA_{1c}, blood pressure and lipids improved markedly from 1996 to 2015 in both specialist and primary care clinics [27]. A study in seven Asian populations ($n=3687$) in 2007–2009 reported that 5.4% of participants reached all three ABC targets [13]. Among those with diabetes from Hong Kong, it was reported that 12% achieved ADA targets, while those from India had the lowest proportion meeting ABC targets at 1.9%. Comparing our results with those from other published studies, Mauritius had the lowest rate of attainment of ABC targets in 2009 at 1.6%, which is similar to the Indian study [13].

A strength of the present study was the nationally representative sample with high response rates, which allowed us to generalize the results to the whole diabetes population of Mauritius. Limitations include the fact that there were differences in some general characteristics of the participants such as age, duration of diabetes and BMI in the two surveys, which might have affected the outcomes. Second, adherence to medication was not assessed, and we relied on self-reported medication use. Third, this analysis did not evaluate lifestyle change, such as patterns of dietary intake and levels of physical activity of participants.

The present study is one of the first assessments of trends in management target achievement among people with diabetes in a lower- or middle-income country. Using two population-based independent survey samples, we found that in 2015 compared with 2009, control of glycaemia and blood pressure was better, and total and LDL cholesterol control remained

unchanged. While we cannot define the reasons for this favourable trend, it occurred in parallel with higher rates of medication use. Better control of HbA_{1c} was mainly observed in groups where control was poorest in 2009, perhaps indicating a narrowing in some of the health inequalities in people with diabetes. Nevertheless, the majority of people with diabetes still had inadequately controlled HbA_{1c}, blood pressure and lipids, stressing the need for further improvements in diabetes management in Mauritius.

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Competing interests

None declared.

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References

1. Sicree RA, Shaw JE, Zimmet PZ: Diabetes and impaired glucose tolerance. In: *Diabetes Atlas*, 4th edn (Gan D ed.). Brussels, Belgium: International Diabetes Federation, 2009, pp. 180.
2. Magliano DJ, Soderberg S, Zimmet PZ, Chen L, Joonas N, Kowlessur S *et al.* Explaining the increase of diabetes prevalence and plasma glucose in Mauritius. *Diabetes Care* 2012; **35**:87–91.
3. Soderberg S, Zimmet P, Tuomilehto J, de Courten M, Dowse GK, Chitson P *et al.* Increasing prevalence of Type 2 diabetes mellitus in all ethnic groups in Mauritius. *Diabet Med* 2005; **22**:61–68.
4. American Diabetes A. Standards of Medical Care in Diabetes-2016 Abridged for Primary Care Providers. *Clin Diabetes* 2016; **34**:3–21.
5. International Diabetes Federation. *IDF Diabetes Atlas*, 6th edn. Brussels, Belgium: International Diabetes Federation, 2013.

6. Executive summary: standards of medical care in diabetes–2009. *Diabetes Care* 2009; **32** (Suppl. 1):S6–12.
7. IDF Clinical Guidelines Task Force. *Global guideline for Type 2 diabetes*. Brussels: International Diabetes Federation, 2005.
8. IDF Clinical Guidelines Task Force. Global Guideline for Type 2 Diabetes: recommendations for standard, comprehensive, and minimal care. *Diabet Med* 2006; **23**:579–593.
9. Yu NC, Su HY, Chiou ST, Yeh MC, Yeh SW, Tzeng MS *et al.* Trends of ABC control 2006–2011: a National Survey of Diabetes Health Promotion Institutes in Taiwan. *Diabetes Res Clin Pract* 2013; **99**:112–119.
10. Cheung BM, Ong KL, Cherny SS, Sham PC, Tso AW, Lam KS. Diabetes prevalence and therapeutic target achievement in the United States, 1999 to 2006. *Am J Med* 2009; **122**:443–453.
11. Janghorbani M, Papi B, Amini M. Current status of glucose, blood pressure and lipid management in type 2 diabetes clinic attendees in Isfahan, Iran. *J Diabetes Investig* 2015; **6**:716–725.
12. Wong KW, Ho SY, Chao DV. Quality of diabetes care in public primary care clinics in Hong Kong. *Fam Pract* 2012; **29**:196–202.
13. So WY, Raboca J, Sobrepena L, Yoon KH, Deerochanawong C, Ho LT *et al.* Comprehensive risk assessments of diabetic patients from seven Asian countries: The Joint Asia Diabetes Evaluation (JADE) program. *J Diabetes* 2011; **3**:109–118.
14. Magliano D, Shaw J, Zimmet P, Soderberg S, Gopee N, Gaoneadry D *et al.* The Rise and Rise of Diabetes and Cardiovascular Disease Risk in Mauritius. Baker IDI Heart and Diabetes Institute 2009.
15. Magliano D, Shaw J, Zimmet P, Pauvaday K, Deelchand A, Kowlessur S *et al.* The Trends in Diabetes and Cardiovascular Disease Risk in Mauritius. Melbourne: Baker IDI Heart and Diabetes Institute, 2015.
16. Hsu WC, Araneta MR, Kanaya AM, Chiang JL, Fujimoto W. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. *Diabetes Care* 2015; **38**:150–158.
17. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 1972; **18**:499–502.
18. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004; **363**:157–163.
19. Stark Casagrande S, Fradkin JE, Saydah SH, Rust KF, Cowie CC. The prevalence of meeting A1C, blood pressure, and LDL goals among people with diabetes, 1988–2010. *Diabetes Care* 2013; **36**:2271–2279.

20. Bala MM, Placzkiewicz-Jankowska E, Lesniak W, Topor-Madry R, Michalejko M, Jankowski M *et al.* Management and treatment goals in Polish patients with type 2 diabetes of short duration: results of the ARETAEUS2-Grupa study. *Pol Arch Med Wewn* 2013; **123**:573–581.
21. Clark CE, Smith LF, Taylor RS, Campbell JL. Nurse led interventions to improve control of blood pressure in people with hypertension: systematic review and meta-analysis. *BMJ* 2010; **341**:c3995.
22. Shamai L, Lurix E, Shen M, Novaro GM, Szomstein S, Rosenthal R *et al.* Association of body mass index and lipid profiles: evaluation of a broad spectrum of body mass index patients including the morbidly obese. *Obes Surg* 2011; **21**:42–47.
23. Vinker S, Shani M, Baevsky T, Elhayany A. Adherence with statins over 8 years in a usual care setting. *Am J Manag Care* 2008; **14**:388–392.
24. Stark Casagrande S, Rios Burrows N, Geiss LS, Bainbridge KE, Fradkin JE, Cowie CC. Diabetes knowledge and its relationship with achieving treatment recommendations in a national sample of people with type 2 diabetes. *Diabetes Care* 2012; **35**:1556–1565.
25. Varma S, Boyle LL, Varma MR, Piatt GA. Controlling the ABCs of diabetes in clinical practice: a community-based endocrinology practice experience. *Diabetes Res Clin Pract* 2008; **80**:89–95.
26. Saydah SH, Fradkin J, Cowie CC. Poor control of risk factors for vascular disease among adults with previously diagnosed diabetes. *JAMA* 2004; **291**:335–342.
27. Svensson AM. 20 years of successful improvements. The Swedish National Diabetes Register, Centre of Registers Västra Götaland 2016.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1.

FIGURE 1 Flow chart of the study population in the 2009 and 2015 surveys.

Table 1 Comparisons of clinical characteristics in people with diagnosed diabetes in 2009 and in 2015

	2009	2015	P*
Number of participants	858	656	
Gender, % (n)			0.28
Men	47.3 (406)	44.5 (292)	
Women	52.7 (452)	55.5 (364)	
Median (IQR) age, years	57.0 (50.0 to 63.0)	59.9 (53.9 to 65.9)	<0.001 [†]
Ethnicity, % (n)			0.78
South Asian	77.2 (662)	75.6 (496)	
African (Creole)	19.5 (167)	20.7 (136)	
Other (mostly Chinese)	3.4 (29)	3.7 (24)	
Mean $\pm$ SD BMI, kg/m ²	26.6 $\pm$ 4.6	27.3 $\pm$ 4.9	0.01
BMI [‡] , % (n)			0.37
Normal	19.7 (168)	17.4 (114)	
Overweight	38.1 (325)	37.2 (244)	
Obese	42.3 (361)	45.4 (298)	
Median (IQR) duration of diabetes, years	5.0 (2.0 to 10.0)	6.8 (3.2 to 12.9)	<0.001 [†]
Duration of diabetes, % (n)			0.53
<5 years	44.4 (366)	38.4 (236)	
5–10 years	22.7 (187)	23.6 (145)	
$\geq$ 10 years	32.9 (271)	38.1 (234)	
Total [§] , N	824	615	
Education, % (n)			0.03
Primary school education or no education	64.2 (546)	57.9 (380)	
Secondary school education	32.3 (275)	39.0 (256)	
Tertiary education	3.5 (30)	3.1 (20)	
Biochemical markers			
Median (IQR) fasting plasma glucose, mmol/l			
Men	9.1 (7.4 to 11.7)	8.4 (7.0 to 10.6)	0.033 [†]
Women	9.9 (7.9 to 12.8)	8.3 (6.7 to 10.9)	<0.001 [†]
Total	9.5 (7.7 to 12.4)	8.3 (8.8 to 10.8)	<0.001 [†]
Median (IQR) HbA _{1c}			
Men			0.278 [†]
mmol/mol	97.2 (53.0 to 86.9)	63.9 (54.1 to 80.3)	
%	8.3 (7.0 to 10.1)	8.0 (7.1 to 9.5)	
Women			<0.001 [†]
mmol/mol	77.0 (60.7 to 97.8)	65.0 (54.0 to 83.6)	
%	9.2 (7.7 to 11.1)	8.1 (7.1 to 9.8)	

Total			<0.001 [†]
mmol/mol	72.7 (57.4 to 92.4)	63.9 (54.1 to 82.5)	
%	8.8 (7.4 to 10.6)	8.0 (7.1 to 9.7)	
Median (IQR) HbA _{1c} , mmol/mol	72.7 (60.7 to 112.0)	67.2 (72.7 to 94.5)	
HbA _{1c} , % (<i>n</i>)			0.12
<53 mmol/mol (<7%)	18.4 (158)	21.8 (143)	
53–63.9 mmol/mol (7–7.9%)	16.7 (143)	25.5 (167)	
64–74.9 mmol/mol (8–8.9%)	17.5 (150)	18.3 (120)	
≥75 mmol/mol) ≥9%	47.4 (407)	34.5 (226)	
Mean ± SD total cholesterol, mmol/l	5.0 ± 1.3	4.9 ± 1.2	0.72
Median (IQR) HDL cholesterol, mmol/l	1.3 (1.1 to 1.6)	1.3 (1.1 to 1.5)	0.117 [†]
Mean ± SD LDL cholesterol [¶] , mmol/l	2.9 ± 0.9	2.8 ± 0.9	0.50
Median (IQR) triglycerides, mmol/l	1.4 (1.0 to 1.8)	1.5 (1.1 to 2.1)	<0.001 [†]
Clinical markers			
Mean ± SD systolic BP, mmHg	146.2 ± 91.5	135.5 ± 85.5	<0.001
Mean ± SD diastolic BP, mmHg	80.9 ± 11.9	81.5 ± 11.8	0.03
Medication, % (<i>n</i>)			
Glucose-lowering			
Monotherapy	33.0 (283)	40.2 (264)	0.002
Dual or triple therapy	15.0 (129)	23.8 (156)	<0.001
Insulin	10.8 (93)	12.5 (82)	0.85
Total [§] , <i>N</i>	505	502	
Antihypertensive	30.9 (265)	52.1 (342)	<0.001
Statin	19.2 (165)	37.8 (248)	<0.001
Smoker, % (<i>n</i>)			
Men	30.7 (124)	22.3 (65)	0.12
Women	2.0 (9)	1.7 (6)	0.84

BP, blood pressure; IQR, interquartile range.

**P* values calculated by regression model for continuous outcomes and logistic regression model for dichotomous outcomes adjusted for age, sex and duration of diabetes, except for duration which is adjusted only for age and sex, and age which is adjusted only for sex and duration of diabetes. *P* values for categorical variables were calculated using the chi-squared test.

[†]*P* values are calculated using a *t*-test after log transforming variables.

[‡]BMI thresholds were ethnic-specific.

[§]When the variable has >10 participants with missing data, the sample size is reported.

[¶]Calculated only using those participants with triglycerides ≤ 4.52 mmol/l.

Table 2 The prevalence of those with diabetes achieving various targets for glycaemic control HbA_{1c} levels in 2009 and 2015

	2009	2015	<i>P</i> [*] (2009 vs 2015)	<i>P</i> [†] interaction
Number of participants	858	656		
HbA _{1c} <53 mmol/mol				
Total	18.6 (16.1 to 21.3)	21.8 (18.8 to 25.1)	0.21	
Gender				0.022
Men	22.9 (19.0 to 27.3)	21.6 (17.2 to 26.7)	0.45	
Women	14.7 (11.7 to 18.3)	22.0 (18.0 to 26.5)	0.01	
Ethnicity				0.517
South Asian	17.4 (14.7 to 20.5)	21.4 (18.0 to 25.2)	0.25	
African (creole)	19.9 (14.4 to 26.7)	22.1 (15.8 to 29.9)	0.52	
Other (mostly Chinese)	37.9 (21.6 to 57.6)	29.2 (13.7 to 51.5)	0.65	
Education				0.227
Primary school or no education [†]	16.7 (13.8 to 20.0)	22.1 (18.2 to 26.6)	0.07	
Secondary school	20.6 (16.2 to 25.9)	21.5 (16.8 to 27.0)	0.91	
Tertiary education	33.3 (18.2 to 52.8)	20.0 (7.0 to 45.3)	0.53	
Duration of diabetes				0.059
<5 years	23.5 (19.4 to 28.1)	30.5 (24.9 to 36.7)	0.19	
5–10 years	20.8 (15.6 to 27.3)	15.2 (10.1 to 22.1)	0.15	
≥10 years	10.8 (7.6 to 15.2)	17.5 (13.1 to 23.0)	0.09	
HbA _{1c} <64 mmol/mol				
Total	35.1 (31.9 to 38.3)	47.2 (43.4 to 51.1)	<0.001	
Gender				0.016
Men	42.8 (38.1 to 47.7)	48.6 (42.9 to 54.4)	0.24	
Women	28.1 (24.1 to 32.4)	46.1 (41.1 to 51.3)	<0.001	
Ethnicity				0.210
South Asian	34.6 (31.0 to 38.3)	48.0 (43.6 to 52.4)	<0.001	
African (Creole)	33.5 (26.7 to 41.1)	45.6 (37.3 to 54.1)	0.01	
Other (mostly Chinese)	55.2 (36.1 to 72.8)	41.7 (22.9 to 63.1)	0.75	
Education				0.102
Primary school or no education [†]	32.8 (29.0 to 36.8)	48.9 (43.9 to 54.0)	<0.001	
Secondary school	38.2 (32.6 to 44.1)	44.1 (38.1 to 50.3)	0.23	
Tertiary education	50.0 (31.9 to 68.1)	55.0 (31.8 to 76.2)	0.53	
Duration of diabetes				0.074

	2009	2015	<i>P</i> [*] (2009 vs 2015)	<i>P</i> [†] interaction
Number of participants	858	656		
<5 years	43.2 (38.2 to 48.3)	60.6 (54.2 to 66.7)	<0.001	
5–10 years	38.0 (31.2 to 45.2)	40.0 (32.3 to 48.3)	0.74	
≥10 years	22.5 (17.9 to 27.9)	39.3 (33.2 to 45.8)	<0.001	
HbA _{1c} <75 mmol/mol				
Total	53.0 (49.6 to 56.3)	65.5 (61.8 to 69.1)	<0.001	
Gender				0.030
Men	59.7 (54.8 to 64.4)	66.4 (60.8 to 71.6)	0.17	
Women	47.0 (42.4 to 51.6)	64.8 (59.8 to 69.6)	<0.001	
Ethnicity				0.587
South Asian	52.9 (49.1 to 56.7)	65.7 (61.4 to 69.8)	<0.001	
African (Creole)	50.0 (42.4 to 57.6)	64.0 (55.4 to 71.7)	0.005	
Other (mostly Chinese)	72.4 (52.5 to 86.2)	70.8 (48.4 to 86.2)	0.98	
Education				0.278
Primary school or no education [‡]	50.2 (46.0 to 54.4)	64.7 (59.8 to 69.4)	<0.001	
Secondary school	57.0 (51.0 to 62.8)	65.6 (60.0 to 71.2)	0.15	
Tertiary education	63.3 (44.0 to 79.2)	80.0 (54.6 to 93.0)	0.08	
Duration of diabetes [§]				0.192
<5 years	60.0 (54.8 to 64.9)	75.8 (70.0 to 80.9)	<0.001	
5–10 years	55.1 (47.8 to 62.1)	60.0 (51.7 to 67.7)	0.43	
≥10 years	41.4 (35.6 to 47.4)	60.2 (53.8 to 66.4)	<0.001	

Data are expressed as percentage (95% CI).

**P* value calculated by logistic regression model adjusted for age, sex and duration of diabetes. [†]*P* values are interactions of sex, ethnicity, education, and duration of diabetes with a change in the proportions of reaching the HbA_{1c} targets between 2009 and 2015. [‡]0 to 6 years of education. [§]Data were available on 1439 participants; for other variables the number of missing is <10.

Table 3 Prevalence of those with diabetes achieving American Diabetes Association targets for blood pressure and lipid levels in 2009 and 2015

	2009	2015	<i>P</i> [*] (2009 vs 2015)	<i>P</i> [†] interaction
Number of participants	858	656		
Blood pressure < 140/90 mmHg				
Total	42.1 (38.8 to 45.5)	57.9 (54.0 to 61.6)	<0.001	
Gender				0.094
Men	41.4 (36.7 to 46.3)	59.2 (53.5 to 64.8)	<0.001	
Women	42.8 (38.3 to 47.4)	56.7 (51.6 to 61.8)	<0.001	

	2009	2015	<i>P</i> [*] (2009 vs 2015)	<i>P</i> [†] interaction
Number of participants	858	656		
Ethnicity				0.095
South Asian	42.2 (38.5 to 46.0)	60.2 (55.8 to 64.4)	<0.001	
African (Creole)	43.7 (36.3 to 51.4)	47.8 (39.4 to 56.3)	0.16	
Other (mostly Chinese)	31.0 (16.3 to 51.0)	66.7 (44.5 to 83.3)	0.02	
Education				0.442
Primary school or no education [‡]	40.3 (36.2 to 44.5)	54.5 (49.4 to 59.4)	<0.001	
Secondary school	44.7 (38.9 to 50.7)	63.5 (57.4 to 69.2)	<0.001	
Tertiary education	50.0 (27.7 to 72.3)	50.0 (27.7 to 72.3)	0.55	
Duration of diabetes				0.211
<5 years	51.2 (43.6 to 53.9)	58.0 (51.6 to 64.2)	0.001	
5–10 years	38.5 (31.7 to 45.7)	60.7 (52.4 to 68.4)	<0.001	
≥10 years	38.0 (32.4 to 44.0)	54.9 (48.5 to 61.2)	<0.001	
LDL cholesterol <2.59 mmol/l				
Total	36.7 (33.5 to 40.0)	42.9 (39.1 to 46.8)	0.14	
Gender				0.714
Men	42.1 (37.3 to 47.1)	50.4 (44.4 to 56.3)	0.27	
Women	32.0 (27.8 to 36.5)	37.1 (32.3 to 42.3)	0.35	
Ethnicity				0.481
South Asian	37.9 (34.3 to 41.8)	42.8 (38.4 to 47.3)	0.72	
African (Creole)	33.9 (27.0 to 41.6)	44.3 (36.0 to 53.0)	0.046	
Other (mostly Chinese)	24.1 (11.4 to 44.0)	36.4 (18.2 to 59.5)	0.46	
Education				0.945
Primary school or no education [‡]	34.8 (31.0 to 39.0)	41.1 (36.1 to 46.2)	0.21	
Secondary school	39.4 (33.6 to 45.4)	44.7 (38.6 to 51.0)	0.58	
Tertiary education	48.3 (30.1 to 67.0)	55.5 (30.9 to 77.8)	0.75	
Duration of diabetes [§]				0.510
<5 years	35.7 (30.8 to 40.8)	38.6 (32.4 to 45.1)	0.69	
5–10 years	32.0 (25.5 to 39.3)	41.1 (33.2 to 49.6)	0.13	
≥10 years	42.5 (36.6 to 48.5)	46.7 (40.2 to 53.2)	0.72	

Data are expressed as percentage (95% CI).

**P* value calculated by logistic regression model adjusted for age, sex and duration of diabetes

[†]*P*-values are interactions of sex, ethnicity, education, and duration of diabetes with a change in the proportions of reaching the lipids and blood pressure targets between 2009 and 2015.

[‡]0 to 6 years of education

⁵Data were available on 1439 participants; for other variables the number of missing is < 10.

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